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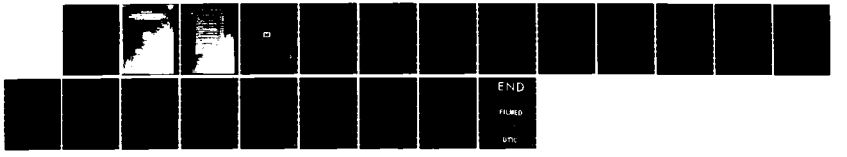

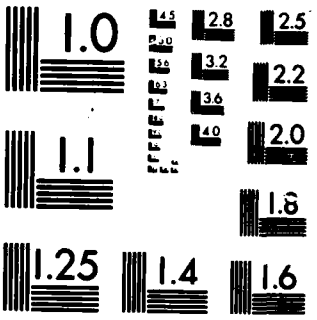

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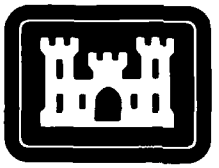
TECHNICAL REPORT NO. 13

COLUMBIA-COWLITZ-TOUTLE RIVERS, WASHINGTON, RESTORATION SUBSEQUENT TO MT. ST. HELENS ERUPTION



September 1985

Committee on Channel Stabilization
CORPS OF ENGINEERS, US ARMY

PRESENT MEMBERSHIP OF COMMITTEE ON CHANNEL STABILIZATION

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Preface

Establishment of the Committee on Channel Stabilization in April 1962 was confirmed by Engineer Regulation 15-2-1, dated 1 November 1962, and reauthorized by ER 15-2-1, dated 25 June 1971 and 30 April 1980. As stated in ER 15-2-1, the objectives of the Committee, with respect to channel stabilization, are:

a. To review and evaluate pertinent information and disseminate the results thereof.

b. To determine the need for and recommend a program of research; and to accomplish advisory technical review of research when requested.

c. To determine basic principles and design guidance.

d. To provide, at the request of field offices, advice on design and operational problems.

This report, prepared by the Committee on Channel Stabilization, for the US Army Engineer District, Portland, represents the opinions and recommendations of the Committee concerning studies leading to restoration of the Columbia-Cowlitz-Toutle Rivers, Washington, subsequent to Mt. St. Helens eruption.

Copies of this and other reports of the Committee on Channel Stabilization can be obtained from the US Army Engineer Waterways Experiment Station, PO Box 631, Vicksburg, Mississippi 39180-0631.

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COLUMBIA-COWLITZ-TOUTLE RIVERS, WASHINGTON
RESTORATION SUBSEQUENT TO MT. ST. HELENS ERUPTION

Introduction

1. On 18 May 1980, Mt. St. Helens, located in southwest Washington (Figure 1), erupted with devastating force causing a huge sand flow down the Toutle River to the Cowlitz River that eventually emptied into and formed a large bar or delta in the Columbia River near its junction with the Cowlitz, reducing the authorized navigation channel depth of 40 ft to no more than 15 ft. Sand flow has been adopted as a descriptive term for volcanic eruptive and untrained materials that traversed and deposited in the Toutle River Basin and the Cowlitz and Columbia Rivers. Subsequently, the US Army Engineer District, Portland, has been working to restore Columbia River navigation and preeruption levels of flood protection along the Cowlitz River.

2. By December 1980, 70 percent of the channel capacity of the Cowlitz had been restored. However, December represents the beginning of the normal flood season; therefore the District was concerned with: (a) how much sediment can be expected from the Toutle River during the upcoming flood season; (b) where in the Cowlitz and Columbia Rivers will deposition take place; and (c) what effect will deposition have on flood levels? To address these questions, the District requested and obtained technical assistance from the US Army Engineer Waterways Experiment Station (WES) to aid District personnel in adapting suitable math models to the lower Cowlitz and lower Toutle Rivers and to develop a plan of study (primarily data collection and analysis) in regard to restoration of the Columbia-Cowlitz-Toutle Rivers.

3. The Committee on Channel Stabilization was invited by the Portland District to view the situation of the Cowlitz and Toutle Rivers and present its comments and suggestions on the plan of study. The Committee accepted the invitation and visited Portland on 3 and 4 December 1980. The following pages present the views of the Committee on the plan of study and some suggestions for additional measures in regard to stabilization and data collection.

Description of Project

4. Cowlitz River. The Cowlitz River is a tributary of the Columbia

River, entering the Columbia at Kelso, Longview, Washington. Flood-control projects on the lower Cowlitz consist of flood protection levees at Longview, Kelso, Lexington, and Castle Rock. Preeruption channel capacity of the Cowlitz below the confluence of Cowlitz and Toutle Rivers was about 70,000 cfs. Levee segments, named above, were designed to provide protection against a 500-year flood (Figure 2).

5. Columbia River. The Columbia River provides year-round deep-draft navigation. Project navigation depths are 40 ft (Figure 1).

Effects of Eruption

6. Cowlitz River. The confluence of the Cowlitz and Toutle River is about mile 20 on the Cowlitz. The sand flows that entered the Cowlitz from the Toutle reduced the average bank-full capacity from about 70,000 cfs to about 13,000 cfs. The magnitude of the sand flow also caused deposition of material in the Cowlitz approximately 5 miles upstream of the confluence of the Cowlitz and Toutle Rivers as well as causing back flow and excessive deposition in small tributaries along the Cowlitz. The Portland District has succeeded in restoring bank-full capacity to about 50,000 cfs and plans to maintain this capacity through the flood season by continued excavation of material transported by the Toutle River. This is still 20,000 cfs short of preeruption capacity; therefore the District is raising, extending, and improving existing protection levees along the Cowlitz in order to provide preeruption project protection.

7. Columbia River. The initial sand flow down the Cowlitz put excess sediments into the Columbia River reducing navigation depths by 25 ft near the mouth of the Cowlitz. Navigation depths have subsequently been restored but large quantities of fine sediment continue to be transported to the Columbia despite continued excavation operations on the Cowlitz.

Portland District Plan of Study Columbia-Cowlitz-Toutle Restoration

8. Objectives.

a. Short-term. Activities required to establish data necessary for decisions regarding first year construction and flood-control regulation in

the Cowlitz-Toutle River Basin, and for maintenance of Columbia River navigation.

b. Long-term. Activities required to establish the rate of approach to regimen status of the Columbia, Cowlitz, and Toutle Rivers, and the Toutle River watershed. Information for this phase is essential as the Corps will be involved in flood-control and navigation aspects of the river system for a number of years.

9. Short-term activities. The short-term activities have already merged into the long-term activities; therefore only the long-term will be outlined.

10. Long-term activities.

a. River surveys. River surveys include the total affected reach of Cowlitz River following major storm events this winter and next spring following the rainy season. These surveys will permit developing a mass balance of sediment in the system, and help estimate the total sediment transport within the river system.

(1) Hydrographic surveys of approximately 25 miles of river. These will provide in-channel data. Surveys will be required several times this winter and next spring.

(2) Overbank surveys will be required to adequately define areas of overbank flooding. The number of surveys needed over the coming winter and spring will be a function of observed overbank deposits.

b. Vertical control surveys. Vertical control must be established for the mudflow, Toutle River, North Fork Toutle, and South Fork Toutle. These data must be developed prior to winter flooding and again next spring. USGS has let contracts for these items, and we will need to budget only for data reduction. This information will allow us to note major movements of material in the mudflows and rivers over the winter and may help develop a mass balance of sediment transport within the system.

c. Sediment sampling program. The USGS will conduct the majority of this effort (Cowlitz River, Toutle River Basin, and Columbia River).

Site No.	Location
(1)	Cowlitz River at Kelso Bridge Bottom material sampled once per month Suspended sediment sampled once per month

(Continued)

Site No.	Location
(2)	Cowlitz River at Castle Rock Bottom material sampled frequently Suspended sediment sampled daily
(3)	Toutle River at Hwy 99 Bridge Bottom material sampled frequently Suspended sediment sampled daily
(4)	Cowlitz River at Toledo Bottom material sampled monthly Suspended sediment sampled monthly
(5)	Toutle River at Silver Lake Bottom material sampled twice per month Suspended sediment sampled daily
(6)	South Fork Toutle River just upstream of confluence with North Fork Bottom material sampled twice per month Suspended sediment sampled daily
(7)	North Fork Toutle River near Kid Valley Bottom material sampled twice per month Suspended sediment sampled daily
(8)	North Fork Toutle upstream of Check Dam N1 Bottom material sampled monthly Suspended sediment sampled automatically
(9)	South Fork Toutle downstream of Check Dam S1 Bottom material sampled monthly Suspended sediment sampled automatically
(10)	Green River Bottom material sampled monthly Suspended sediment sampled monthly
(11)	Columbia River at three sites: upstream of Cowlitz River confluence; immediately below confluence; and downstream of confluence at Beaver Army Terminal.

A verbal proposal from the USGS's Portland office has been received for suspended sediment sampling and developing a computer flow model to calculate total sediment load. This is still in the planning phase, but USGS's estimate is included. The three sites on the Columbia River are considered essential to the overall study. All other sites will be maintained and monitored by the Tacoma USGS office.

Corps involvement beyond this effort includes our need for bottom material samples at a number of cross sections on a 25-mile reach of the Cowlitz and 2 to 3 miles upstream of the mouth on the Toutle. This information is essential for any adequate computer modeling of sediment transport. Data will be gathered this winter.

d. Sediment analysis for physical properties (Cowlitz River, Toutle River Basin, and Columbia River).

(1) Sediment analysis

(2) Visual accumulator

(3) Specific gravity

(4) Void ratio

(5) Angle of repose

(6) Fall velocity

The USGS will conduct the majority of analyses, though the Corps will conduct some work in the Troutdale Laboratory.

e. Instrumentation.

(1) Stage. Stage will be monitored by the USGS at a number of stream gages on the Toutle, Cowlitz, and Columbia Rivers. The cross-sectional geometry at these sites will be constantly changing over the winter because of the large sediment load. USGS will meter every 2 weeks to maintain a rating at these gages. Crest gages will also be required to monitor flood heights. Hydrology Section will install these crest stage gages along the Cowlitz River and lower Toutle River by early November 1980. Monitoring will be required throughout the winter season. These gages will provide information about maximum flood stages and additional data about sediment movement in the river.

(2) Discharge. Stage recorders will not provide the information needed to evaluate flood flows during storm events, so it will be necessary for the Corps to have a stream-gaging program this winter. Metering will be done over the storm duration at several sites, including at least one site each on the North Fork Toutle, South Fork Toutle, Toutle main stem, and Cowlitz main stem. This information is required for rainfall-runoff modeling, which will allow further analysis of flood-control problems on the Cowlitz River.

(3) Meteorological data will be acquired by National Weather Service. This information used in conjunction with stream gaging will help

define the new rainfall-runoff relation in the Toutle-Cowlitz Basin. Only data reduction will be required by the Portland District.

(4) Sediment. Monitoring of sediment inflow into the sump at the mouth of Toutle River over the winter will be required. Intermittent surveys of the sump will help in estimating sediment transport and deposition in the Toutle and Cowlitz Rivers.

f. Math modeling.

(1) Water-surface profiles using HEC-2 backwater program will be developed for various levels of flow and sedimentation in the Cowlitz River as conditions change during the year.

(2) Sediment transport will be modeled using HEC-6 or another appropriate computer program on the Columbia and Cowlitz Rivers, and 2 to 3 miles upstream on the Toutle. No detailed calibration of this model can be done before the completion of present construction and data acquisition phase. Initial setup of the model can proceed, but the majority of this effort will be next spring. Appropriate computer modeling, along with sediment sampling and a system mass balance approach, will help provide a sediment transport predictive capability.

(a) Arrange for use of HEC and WES computer models.

(b) Arrange for training and consulting services with these groups.

(3) Watershed model primarily concerns hydrologic modeling of the Toutle River watershed. Until acquisition of data this winter, only initial model setup can proceed. Majority of the modeling effort will be next spring. Rainfall-runoff relations are necessary to make estimates of sediment transport and to evaluate flood problems on the Cowlitz River.

(a) Arrange for use of HEC or other viable modeling.

(b) Arrange for training and consulting services.

g. Interagency coordination is needed to avoid overlap and to facilitate exchange of information.

(1) USGS

(2) Forest Service

(3) SCS

(4) NWS - flood warning

(5) Other

Committee Appraisal of Plan of Study

11. General. All of the work outlined in the plan of study is necessary and important with the possible exception of sediment load measurements on the Columbia River. The Committee has no estimate of how long it will take for the Toutle watershed and the North and South Forks of the Toutle to regain a stable regimen. However, the Committee does feel that the long-term picture, assuming no future dramatic eruptions and/or extreme hydrological events, will be one of exponential decline of average annual sediment contribution to the Cowlitz. This feeling is based on observation of vertical faces, resulting from downcutting of North Fork of Toutle downstream of the North Fork Debris Retaining Structure, that show the presence of a large quantity of interspersed very coarse material which should provide a potential for bed armoring limiting available sources of material and allowing the stream time to adjust to a new regime as natural stabilization of valley walls and floor develops. In this regard, the long-term Corps requirements could materially benefit from any practical alternative of enhancing stabilization rates in the Toutle watershed; therefore the Portland District is encouraged to take advantage of any opportunity to encourage other agencies involved on the Toutle watershed to consider stabilization alternatives, seeding, planting of seedlings, etc. In this regard, the Committee suggests that it may be worthwhile to determine the chemical quality of the subject material to identify its potential for sustaining vegetation. Stabilization measures should not be confined to those that seek to hold the Toutle River in or near its original bed. The valley slope of the Toutle River Basin has increased appreciably due to excessive material deposited in the upper part of the basin. Hence, in order to achieve a stable gradient, the channel will likely require an increase in length above that of the original channel. Channel stabilization works that would serve to lengthen the channel, thereby conceivably decreasing sediment transport, should be considered.

12. The plan of study does not include provisions for means to estimate the amount of sediment ultimately available on the Toutle for transport. Estimates of this nature, however rough they might be, should be made and used in formulating long-term-probable Corps requirements. Seismic techniques might prove useful in this regard (EM 1110-2-1802, "Subsurface Investigation Geophysical Explorations").

13. The material that is being excavated from the Cowlitz and placed in the floodplain will be susceptible to erosion from local rainfall runoff, bank caving, and overbank flooding, particularly overbank flooding. The potential for severe erosion and redeposition in the Cowlitz channel is real and will continue for several years in the future unless measures are taken to stabilize this material. Portland District should look at environmentally and socially acceptable measures to stabilize the excavated material, with careful coordination and cooperation with local interest, environmental, and other agencies. In areas where the Portland District has no responsibility but favorable coordination and cooperation with those who do have responsibility, it should emphasize stabilization of material that has been placed and/or naturally deposited.

14. Surveys. Survey needs described in the plan of study are concurred in.

a. In addition to the survey requirements outlined, it is suggested that low-level aerial photography over the Toutle be added to the survey program. A significant mass of material remains in the Toutle River system. The natural regime of the Toutle was completely destroyed, requiring nature to develop the system again. Chronological assessment of channel development, especially channel widths and alignments through the collection of low-level uncontrolled mosaics, will be extremely useful in evaluations and prediction of sediment yields of the Toutle system. Aerial photography offers an excellent means of assessment and such an assessment may significantly reduce the necessity of prototype surveys.

b. A geological field survey of the Toutle system is also suggested (eye survey). During the field trip on 3 December, significant vertical downcutting of the North Fork of Toutle River below the debris-retaining structure exposing many vertical faces was noted. Inspection of those vertical faces by a trained geologist should provide valuable information on probable depth of fill, stratification of materials, rough gradation of material, etc. This type of data should be useful in estimating gross sediment sources and supply, potential for bed armoring, potential for natural stabilization development, etc. Potentially useful information might also be gained from a visual inspection of the material dredged from the mouth of the Toutle River and along the Cowlitz downstream from the mouth.

15. Sediment sampling program. The program outlined is concurred in

except for the three Columbia River sites (Site 11); but the program should be supplemented with a more concerted effort to obtain bottom samples of the Columbia River in the vicinity of the confluence of the Cowlitz and downstream. The characteristics of the material entering the Cowlitz from the Toutle appears unique and should be easily identifiable if present in appreciable quantities along the Columbia River. Collection of this type of data can provide a fairly rapid evaluation of the Columbia-Cowlitz sediment transport relation. In addition, it is recommended that in addition to the in-place voids ratio (e), the voids ratio for the maximum and minimum densities (e_{max} and e_{min}) be determined.

16. The Committee questions the USGS proposal to make sediment load measurements at three sites in the Columbia in order to determine the load out of the Cowlitz. Measurements in a river the size of the Columbia would be time-consuming and very expensive. The most effective way of determining the approximate load out of the Cowlitz would be to concentrate measurement efforts at Kelso in the Cowlitz itself. The magnitude of effort would be significantly reduced, and the loads measured at Kelso would probably be fairly representative of loads contributed to the Columbia by the Cowlitz. This information supplemented by routine hydrographic surveys in the Columbia should be sufficient to evaluate the Columbia-Cowlitz sediment transport relation.

17. It is noted that the USGS has primary responsibility for sediment sampling and analysis and the Corps receives necessary sediment data through a cooperative effort. Although there appears to be a satisfactory atmosphere of cooperation between respective agencies, the Portland District should develop some in-house capability for collecting sediment data necessary to help ensure the continuous evaluation of the Toutle, Cowlitz, and Columbia Rivers. The problem is long term, a decreasing but none the less long term, and the future needs of the USGS could deviate substantially from the data needs of the Corps. The Corps should reevaluate data needs annually and compare needs with the scheduled data collection program or programs of other agencies.

18. Instrumentation. In addition to the provisions for stage, discharge, meteorological, and sediment data collection, it is recommended that data be collected on the bed-form regime of the Cowlitz River. This can be readily accomplished by taking a few, relatively short, longitudinal profiles of the riverbed after each discharge measurement. This would be useful

information in developing reliable detailed water-surface profiles for different flows and would not increase data collection cost.

19. Math modeling. The effort in terms of math modeling described during the briefing sessions and also in the plan of study are necessary, important, and considered adequate to meet the short- and long-term needs of the Corps. The Corps should periodically reevaluate data collection programs to assure that data necessary to fully utilize the potential of the math models, particularly in the long term, are or will be available through another agency or by the Corps. The sediment data collection program is an essential component to the modeling effort. Until the model is adjusted and verified to reproduce observed transport rates, there can be little confidence in modeling results.

20. Interagency coordination. Interagency coordination is desirable and necessary. There appears to be a favorable atmosphere of cooperation and coordination at the present; however, the Corps should keep in mind that this is a long-term situation and coordination efforts should consider the long term as well as the short term.

21. Debris retaining structures. A debris-retaining structure was constructed on each fork of the Toutle River (Figure 1) for the purpose of trapping sediment, thereby keeping it out of the Cowlitz and Columbia Rivers. Justification for the structure was that a bucket of material removed from the Toutle River equaled one less bucket of material to be handled in the Cowlitz and Columbia Rivers. Portland District indicated and it was observed on the 3 December field trip that each structure filled rapidly. Subsequently, the District began removing material upstream of South Fork structure and planned to initiate similar operations at the North Fork structure. The Committee suggests that the District take a serious look at the real benefit of these structures. In the short term, the material removed from the system by the structure may not affect the sediment loads arriving at the mouth of the Toutle at all. The Toutle has a definite transport capacity and assuming unlimited supply of material upstream and downstream of these structures, material removed by the structures will be replaced by material available for transport downstream of the structures. Over the long term, the operation of trapping and removing material, causing scour and downcutting of the river below the structures, could be detrimental rather than beneficial. The floor of the upper valley of the Toutle River has been raised. If allowed to establish a

new regime, supplemented by an armoring process and encouraged by stabilization efforts, the Toutle could acquire a new slope commensurate with slopes produced by the raising of the valley floor. This process, which is a natural process, could be far more beneficial in annual reduction of sediment loads transported than the present plan of operation at the two structures which in fact disrupts the natural healing process.

Recommendations

22. The Committee recommends the following:

a. In cooperation with other agencies, make an estimate of the magnitude of material ultimately available for transport by the Toutle River to the Cowlitz River.

b. Formulate and execute a program of low altitude aerial photography over the Toutle River.

c. Conduct a detailed geological survey (visual) over the North and South Forks of the Toutle River.

d. Formulate and execute a program of bed material data collection and analysis on the Cowlitz and Columbia Rivers.

e. Concentrate suspended sediment load measurements at Kelso in the Cowlitz in lieu of operating the three proposed suspended sediment sampling stations on the Columbia.

f. Investigate viable, practical alternatives for stabilization of the dredged material placed in the floodplain of the Cowlitz River.

g. Encourage, during interagency coordination, consideration of viable, practical alternatives to stabilize areas of deposition in the Toutle River system.

h. Request from the Scientific Data Information Retrieval System, WES, a literature search for information that could be useful in prediction of future conditions along the Toutle-Cowlitz-Columbia River system.

Summary

23. The ongoing and planned work for the long term is necessary and important to adequately evaluate river conditions and make reasonable predictions for the long term. The Committee has no estimate of how long it

will take for the subject river systems to regain regime status but unfavorable conditions will exist for several years. It will be necessary for the Portland District to reevaluate the situation annually and adjust plans of action accordingly. The services of the Committee on Channel Stabilization are available to the District at any time.

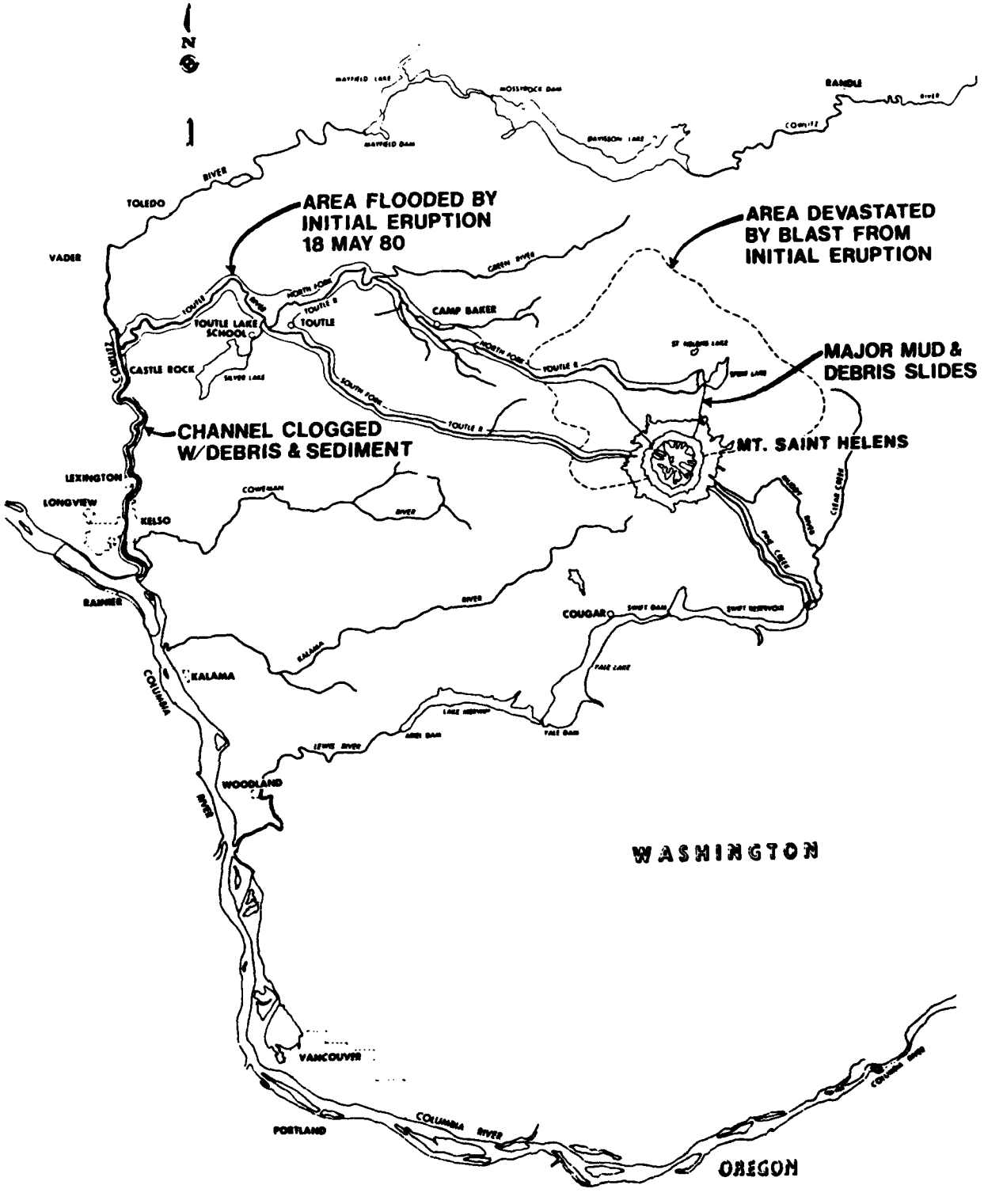

Figure 1. Location map

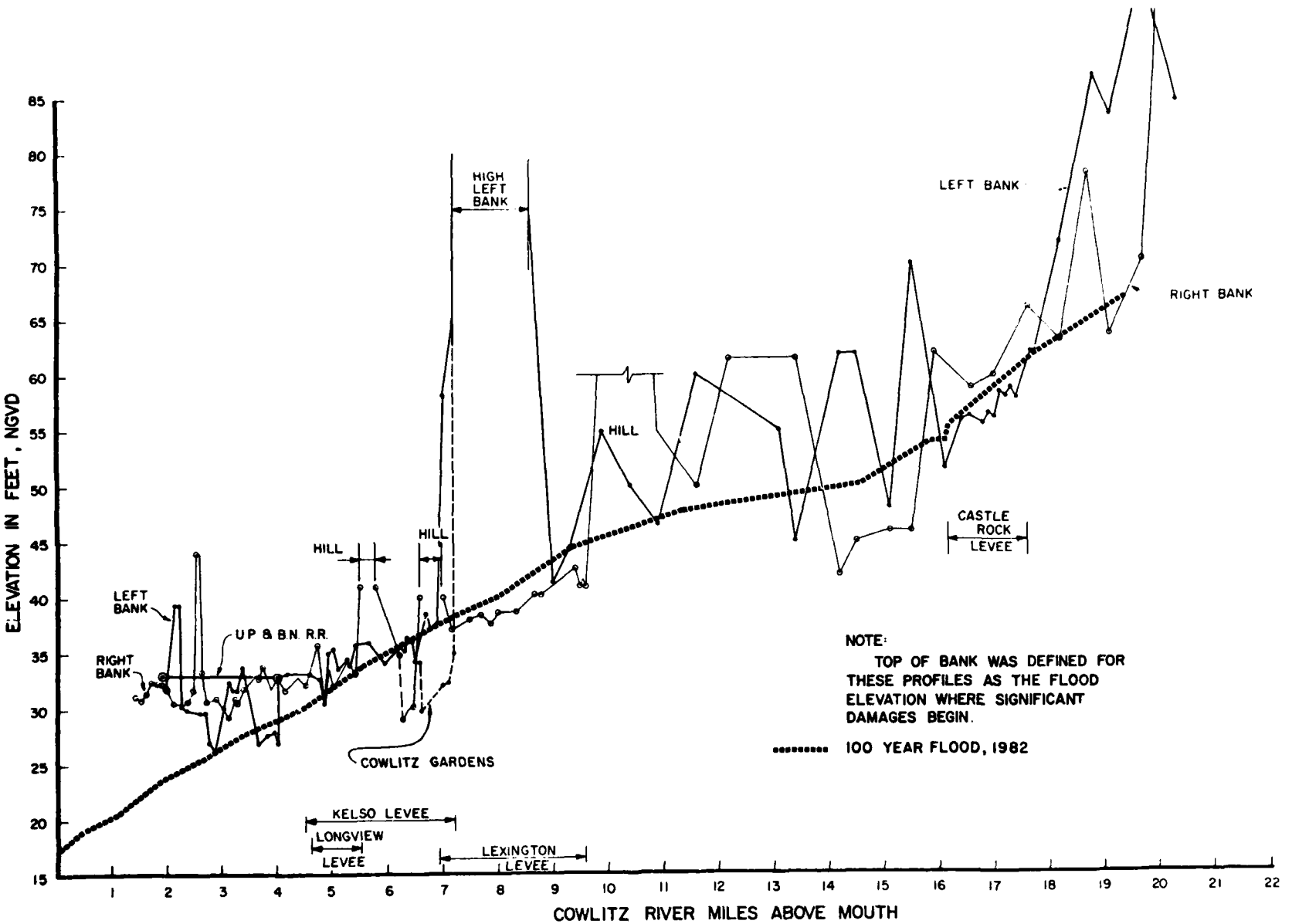

Figure 2. Cowlitz River flood profiles, showing levee segments

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